Agilent

Compatibility of the U2000 Series USB Power Sensors with Agilent Instruments

Application Note

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U2000 Series USB Power Sensor as an Agilent Instrument Accessory

Making an accurate power measurement requires both a power meter and a power sensor. The power sensor converts the RF signal and microwave signal into analog signals. Subsequently, the power meter will perform the statistical processing and display the result in decimal format. Today, the Agilent U2000 Series USB power sensors connect to a PC via the USB port, providing power measurements ranging from +20 dBm to –60 dBm, and over frequencies ranging from 9 kHz to 24 GHz. The combination of power meter and power sensor makes the U2000 Series USB power sensor a standalone instrument that provides an affordable solution for power measurement. Results of the power measurement can be retrieved through the power measurement software on the PC via USB cable or via SCPI commands. The U2000 Series USB power sensors are also compatible with Agilent instruments such as the vector network analyzer, spectrum analyzer, signal generator, cable and antenna tester, and FieldFox RF analyzer.

This application note explains how the U2000 Series USB power sensor performs source power calibration with the N5230A PNA-L and scalar analysis of a frequency converter with E5071C ENA vector network analyzer. The U2000 Series USB power sensors are able to turn the N9340A handheld spectrum analyzer into a power meter function and also perform user flatness correction (UFC) with external leveling using the N5183A MXG signal generator.

Introduction

The U2000 Series USB power sensors are USB-based power sensors, which are more affordable and lighter in weight than typical power meters (see Figure 1). The USB power sensor can measure true average power from the RF and microwave device and thus makes the power sensor similar to power-sensing solutions. Current power measurement solutions require the power sensor to be connected to a power meter in order to perform measurements.

Figure 1 U2000 Series USB power sensor

The new breakthrough design of the U2000 Series USB power sensors enables the sensors to function as standalone instruments that can operate with a PC to provide the power measurement. The plug-and-play USB connectivity provides fast and easy setup. The power sensor also eases monitoring and troubleshooting with the features-packed N1918A Power Analysis Manager software.

Features

- Frequency ranging from 9 kHz to 24 GHz (sensor dependent)
- Wide dynamic range of –60 dBm to +44 dBm
- Internal triggering capability without the need for an external triggering module and power supply
- Internal zeroing capability that eliminates the need for external calibration
- High measurement speed of up to 250 readings per second
- Power measurement in PC or selected Agilent instruments
- True average power measurement for all signal types with unlimited bandwidth

U2000 Series USB Power Sensor's Compatibility with Agilent Instruments

The Agilent instruments such as vector network analyzers, spectrum analyzers, signal generators, cable and antenna testers, and FieldFox RF analyzer are now compatible with the U2000 Series USB power sensors (see Table 1 and Figure 2). Each compatible instrument has built-in firmware to support the USB power sensor, unless it specifically requires N1918A Power Analysis Manager software or the Visual Basic Assistant (VBA) application. You must upgrade your instrument's firmware to the latest revision (see Table 1) through the Agilent Web site, in order to enable the features and compatibility.

Vector Network Analyzer (PNA, PNA-X and PNA-L)
To perform the source power calibration and provide the output power to measure gain compression, intermodulation distortion, and other device parameters accurately.

Vector Network Analyzer (ENA)
To perform scalar analysis of a frequency converter, which requires the VBA application. The ENA also perform the source power calibration and provide the output power to measure gain compression, intermodulation distortion, and other device parameters accurately.

Signal Generator (MXG)
To perform user flatness correction (UFC) with external leveling. Supports and displays two USB power sensor measurement on the MXG display.

Handheld/RF Spectrum Analyzer, Cable and Antenna Tester, and FieldFox RF Analyzer/VNA
Turns the instrument into a power meter. Displays power measurement with its user interface (UI), which integrates the display of USB power sensor measurements.

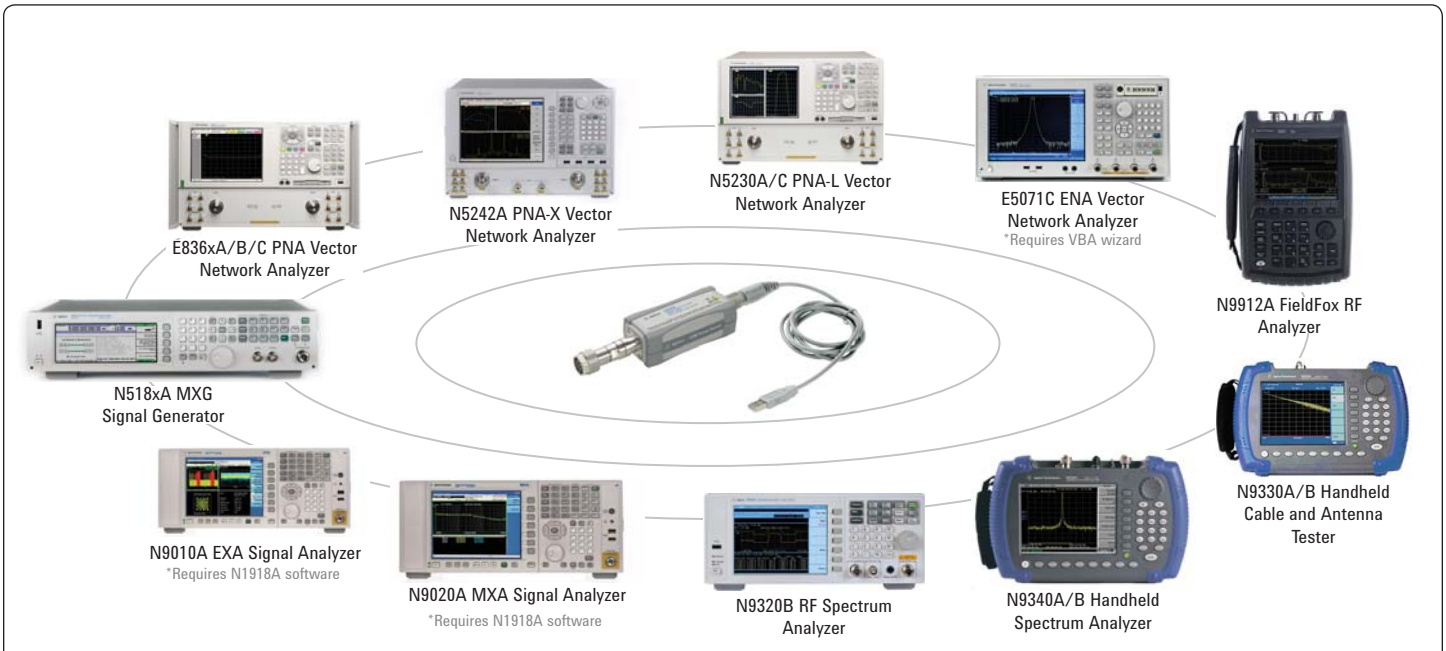
Spectrum Analyzer (MXA, EXA and PXA)
To display the power measurement on spectrum analyser with the free N1918A Power Analysis Manager software.

Table 1 Firmware release and revision compatible with USB power sensor

Instrument	Model No.	Firmware Revision
Vector Network Analyzer	PNA: E836xA/B/C PNA: N522xA PNA-X: N5242A PNA-L: N5230A/C ENA: E506xA/B	A.07.50.13 and above A.09.42.16 and above A.07.50.13 and above A.10.06 and above*1 A.02.06 and above*1
Spectrum Analyzer	Handheld: N9340A/B RF Spectrum Analyzer: N9320B MXA: N9020A EXA: N9010A PXA: N9030A	A.01.05 and above B.02.20 and above A.01.74 and above*2 A.01.74 and above*2 A.04.05 and above*2
Signal Generator	MXG: N518xA and N516xA	A.01.31 and above
Cable and Antenna Tester	Handheld: N9330A/B	A.01.05 and above
FieldFox RF Analyzer	N9912A FieldFox RF Analyzer N9923A FieldFox RF VNA	A.02.05 and above A.05.53 and above

*1 Able to perform scalar analysis of a frequency converter which requires the VBA application, and able to perform source power calibration with built-in firmware.

*2 Refer to the Power Analysis Manager N1918A Installation Guide (N1918A-90002) for PC hardware requirements.


E836xA/B/C PNA Vector Network Analyzer
N5242A PNA-X Vector Network Analyzer
N5230A/C PNA-L Vector Network Analyzer
E5071C ENA Vector Network Analyzer
*Requires VBA wizard
N9912A FieldFox RF Analyzer
N518xA MXG Signal Generator
N9330A/B Handheld Cable and Antenna Tester
N9010A EXA Signal Analyzer
*Requires N1918A software
N9020A MXA Signal Analyzer
*Requires N1918A software
N9320B RF Spectrum Analyzer
N9340A/B Handheld Spectrum Analyzer

Note: Each compatible instrument comes with built-in firmware to support the USB power sensor, unless specified whereby it requires N1918A Power Analysis Manager or VBA wizard.

Figure 2 U2000 Series USB power sensors' compatibility with Agilent instruments

How Does It Work?

N5230C PNA-L Vector Network Analyzer

- To perform the source-power calibration.
- To provide output power in order to measure gain compression, inter-modulation distortion, and other device parameters accurately.

With source power calibration, the power at a certain point is calibrated, to be within the range of the uncertainty of the power meter and sensor. For details of the Source Power Cal procedure, please refer to the Agilent Web site's PNA Source Power Cal procedure online help file (Power Calibration, under the Calibrating a Measurement section). You can readily obtain the procedure from Network Analyzer's Help menu.

Traditionally, the source power calibration is performed through GPIB connectivity and supported by the Agilent power meter and sensor (see Figure 3). This solution requires a big space for storing the power meter and sensor in the production test, along with considerable expense, to acquire power meter and sensor just for Source Power Cal purposes.

Today, the U2000 Series USB power sensors offer a solution that is integrated with the PNA. The U2000 Series USB power sensors are used to replace both power meter and sensor (see Figure 4) in the source power calibration process. It provides the direct connection into PNA USB port via USB plug-and-play connectivity. Throughout the Source Power Cal process, PNA can be configured to detect the power meter (via GPIB) or USB power sensor (via USB) from the power meter setting of the PNA (see Figure 5).

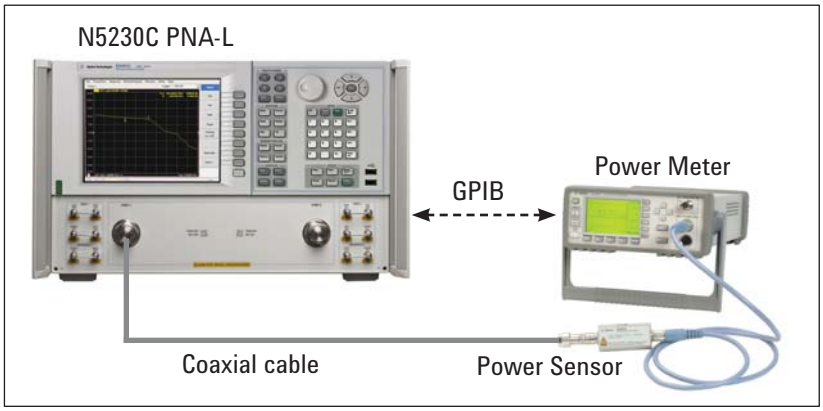


Figure 3 Source Power Cal using both power meter and power sensor connected to PNA through GPIB connection

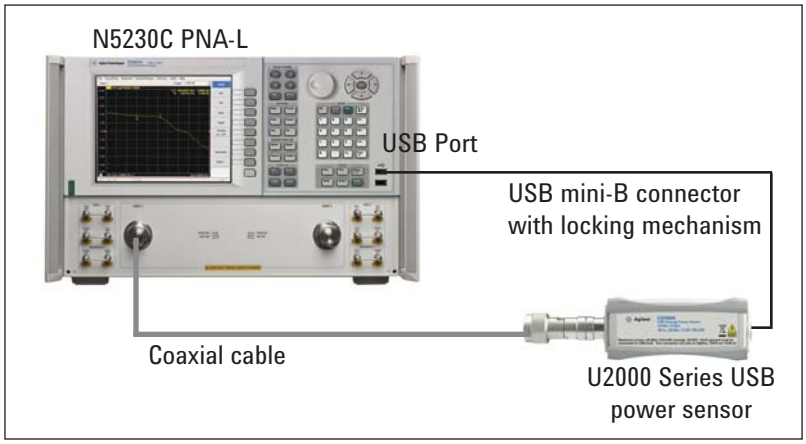


Figure 4 USB power sensor connecting directly to a PNA USB port through USB mini-B connector

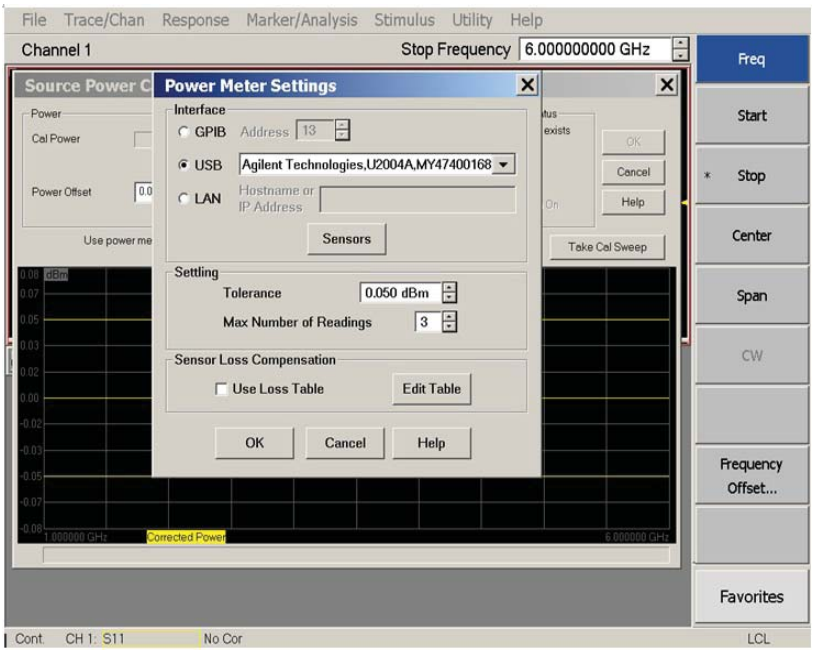


Figure 5 PNA's power meter setting for configuring USB sensor via USB connectivity

How Does It Work? (continued)

Figure 6 and Figure 7 show the results of source power calibration for EPM and USB power sensors respectively. The PNA source is stepped through the specified range (in this example, stepped from 1 GHz to 6 GHz), and power (at 0 dBm) is measured with the power meter and USB power sensor. At each data point, the source power is adjusted until the measured power is within the specified accuracy level.

The source power calibration results can be saved in a Microsoft® Excel file and the two results combined in a single graph for comparison (see Figure 8). The results appear to be comparable and within the ±0.05 db limit line.

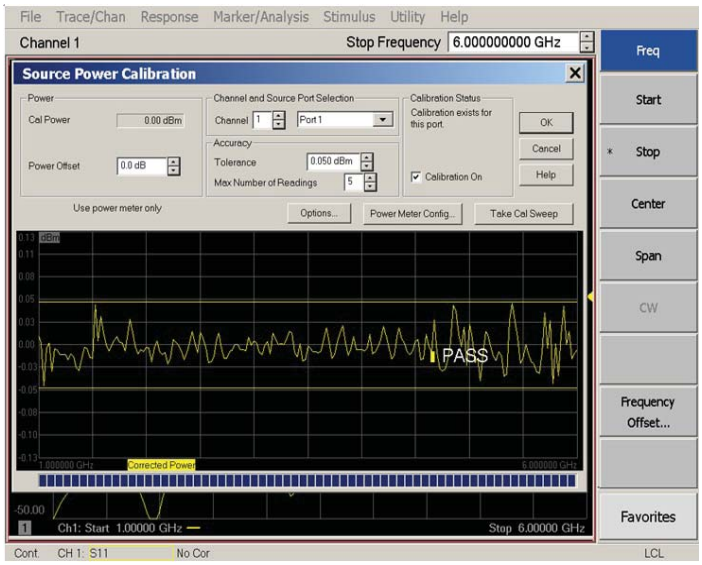


Figure 6 Source power calibration result with EPM and E9301A power meter and sensor

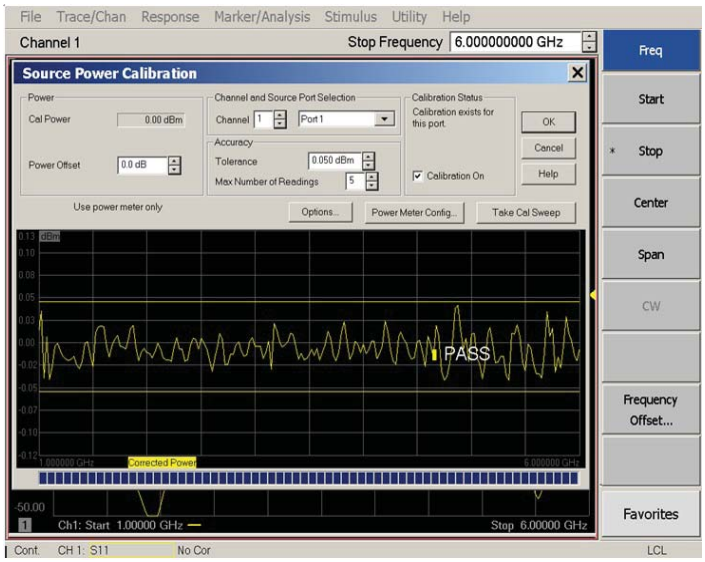


Figure 7 Source power calibration result with U2000 Series USB power sensor

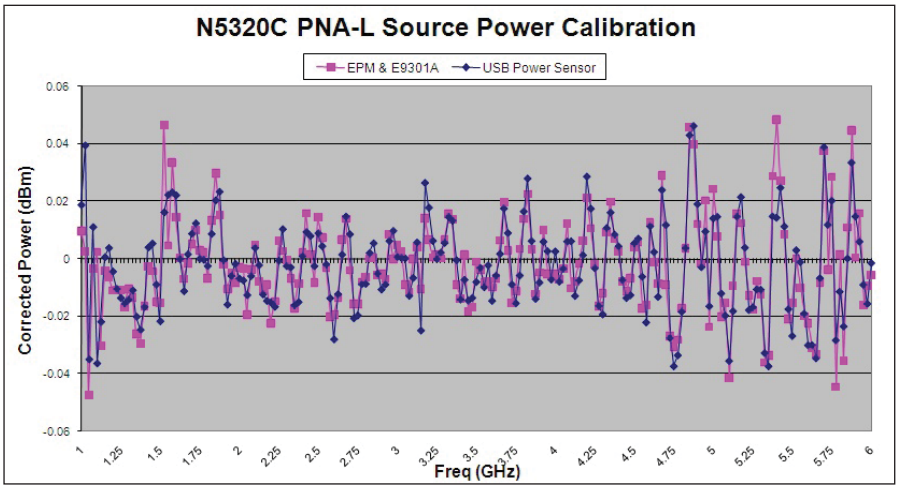


Figure 8 EPM power meter and USB power sensor source power calibration data comparison

How Does It Work? (continued)

E5071C ENA Vector Network Analyzer

- To perform scalar analysis of a frequency converter which requires a VBA application through U2000 Series USB power sensor.

ENA has a frequency offset mode (FOM) option used to measure the frequency converter device accurately. The "offset" of source and receiver port frequency can be defined precisely. The receiver port can detect the down-converter or up-converter signal. There are limitations to using FOM to measure the frequency converter device. First, the local oscillator (LO) signal of the device under test (DUT) has to be known and locked to the source or receiver port frequency of a network analyzer. Otherwise, the difference between predicted intermediate frequency (IF) signal and actual IF signal is directly converted to a magnitude error because of the intermediate frequency bandwidth (IFBW) filter shape implemented in these network analyzers.

Figure 9 shows the ENA setup in FOM mode. IFBW is set to 1 kHz, and the 3 dB BW of the IFBW filter is approximately 1 kHz. If the actual output frequency of the DUT has offset as 500 Hz (=BW/2) from target frequency, the magnitude result has a 3 dB error. When the output signal drifts, the measurement results are also changed at the same time.

You can overcome the limitation of FOM by using the USB power sensor (with network analyzer VBA, sample wizard is available) as a "broadband power detector" (see figure 10). The USB power sensor is used to measure all power in its bandwidth, and the measurement result is stable and not influenced by output signal offset or drift (see Figure 11). For instance, the USB power sensor provides USB plug-and-play connectivity and easy setup in the network analyzer.

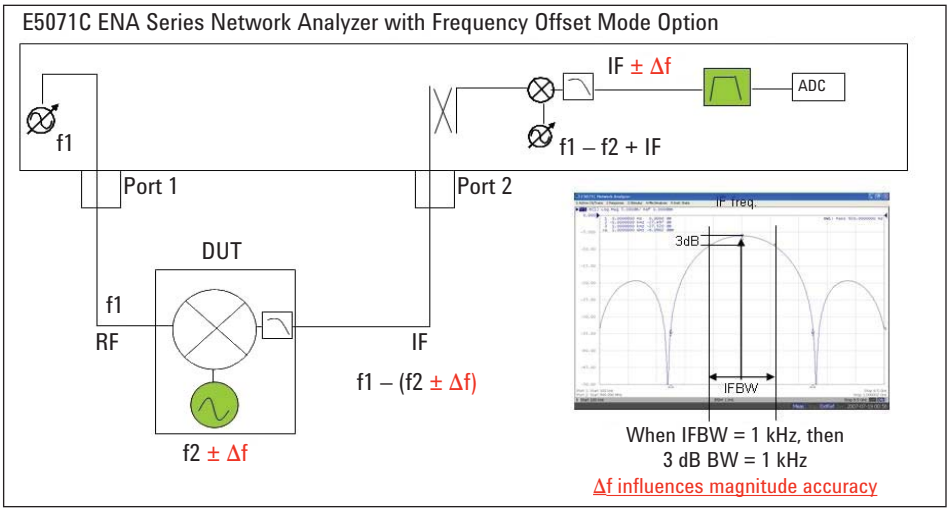


Figure 9 IFBW versus LO frequency drifts with FOM mode

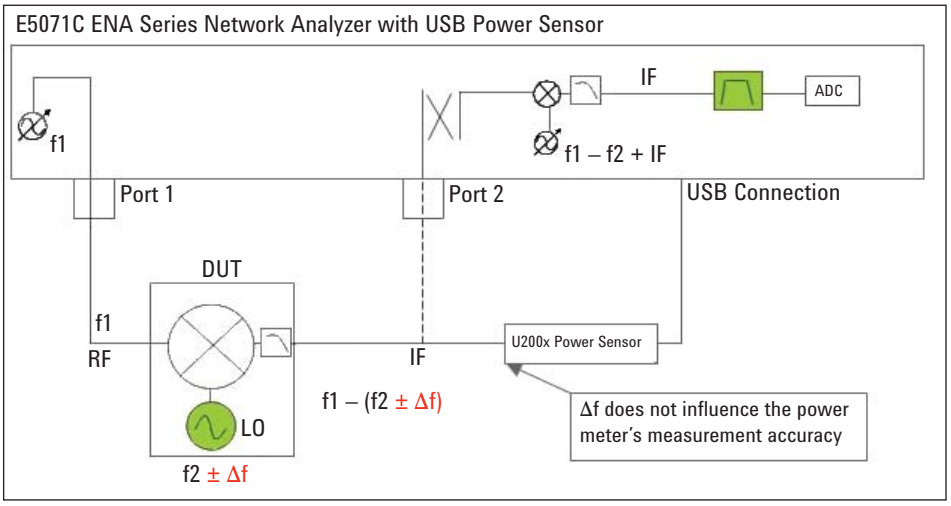


Figure 10 USB power sensor (broadband detect) versus LO Frequency drift

How Does It Work? (continued)

Figure 11 and Figure 12 show the measurement result of "locked" and "drifted" LO signal by FOM mode (see the blue trace) and USB power sensor (see the red trace) respectively. The measurement result of the USB power sensor shows that it has good correlation with the FOM result at locked signal, and is stable with drifted LO signal.

For details of the frequency offset procedure and operation of VBA with the USB power sensor, please refer to the *"Agilent Simple Scalar Network Analysis of Frequency Converter Devices using U2000 USB Power Sensor Series with ENA Series Network Analyzers, Application Note"*

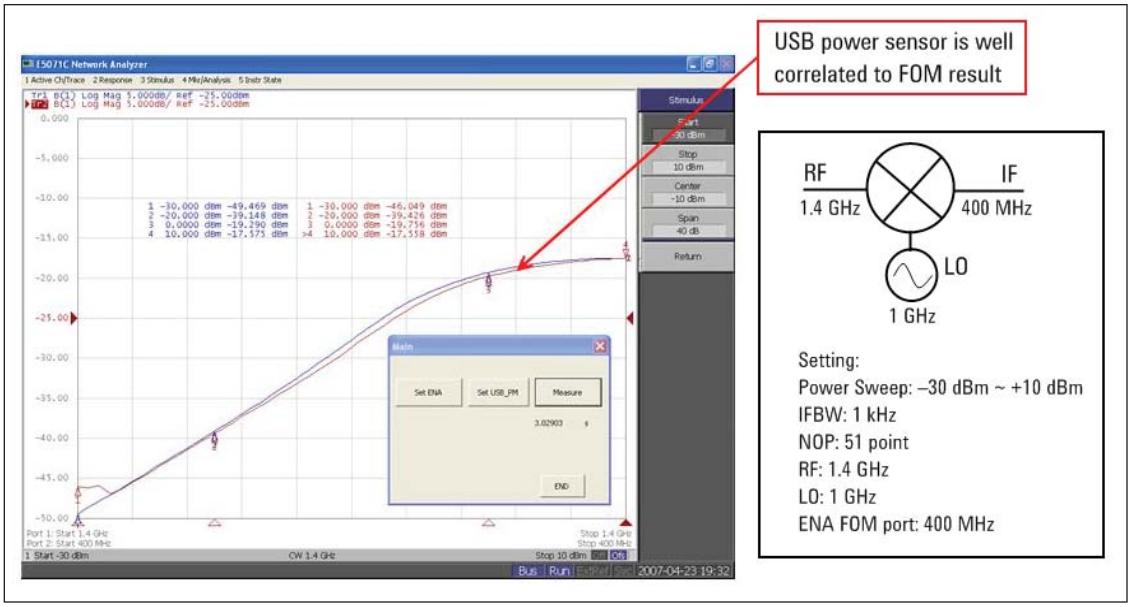


Figure 11 Measurement results with "Locked" LO (RF Power versus IF Power)

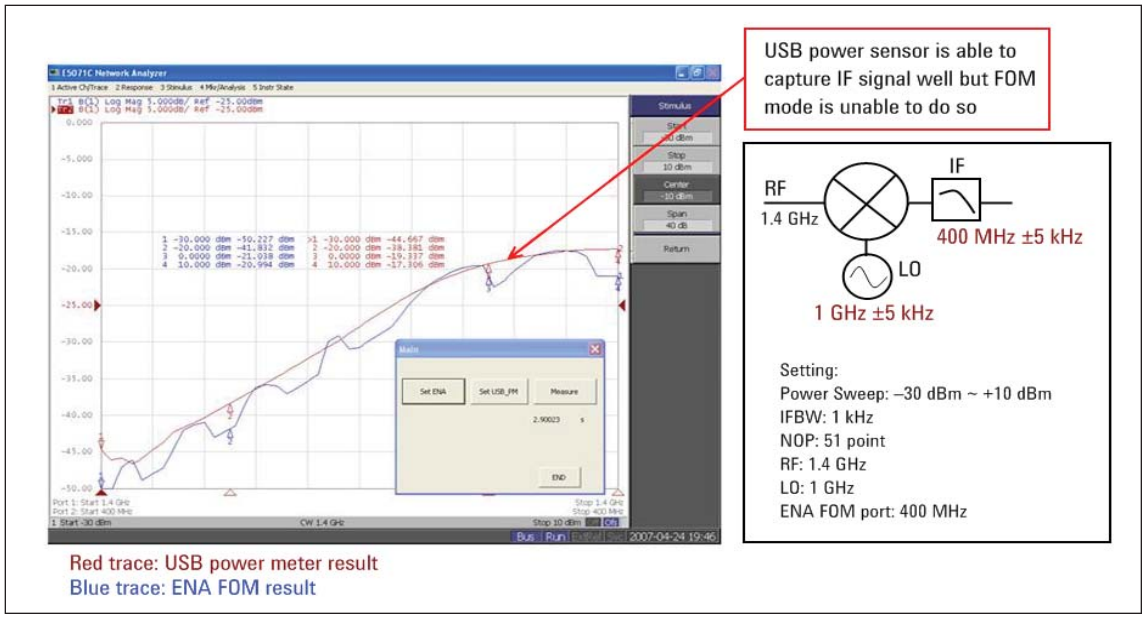

USB power sensor is able to capture IF signal well but FOM mode is unable to do so
RF
1.4 GHz
IF
400 MHz ±5 kHz
LO
1 GHz ±5 kHz
Setting:
Power Sweep: –30 dBm ~ +10 dBm
IFBW: 1 kHz
NOP: 51 point
RF: 1.4 GHz
LO: 1 GHz
ENA FOM port: 400 MHz
Red trace: USB power meter result
Blue trace: ENA FOM result

Figure 12 Measurement results with "Drifted" LO (RF Power versus IF Power)

How Does It Work? (continued)

N9340A Handheld Spectrum Analyzer

- Turns the handheld spectrum analyzer into power meter. Displays power measurement with its user interface (UI), which integrates the display of power measurements.

Keystrokes surrounded by [ ] represent front-panel hardkeys of the instruments, while keystrokes surrounded by { } represent softkeys.

Instructions

1. Power up the N9340A. Connect the U2000 Series USB power sensor to the USB port of the N9340A (see Figure 13).

Figure 13 HHSA connect with USB power sensor.

2. Press [Mode], use [↑] or [↓] key to select the {Power Meter} then press [ENTER] (see Figure 14).

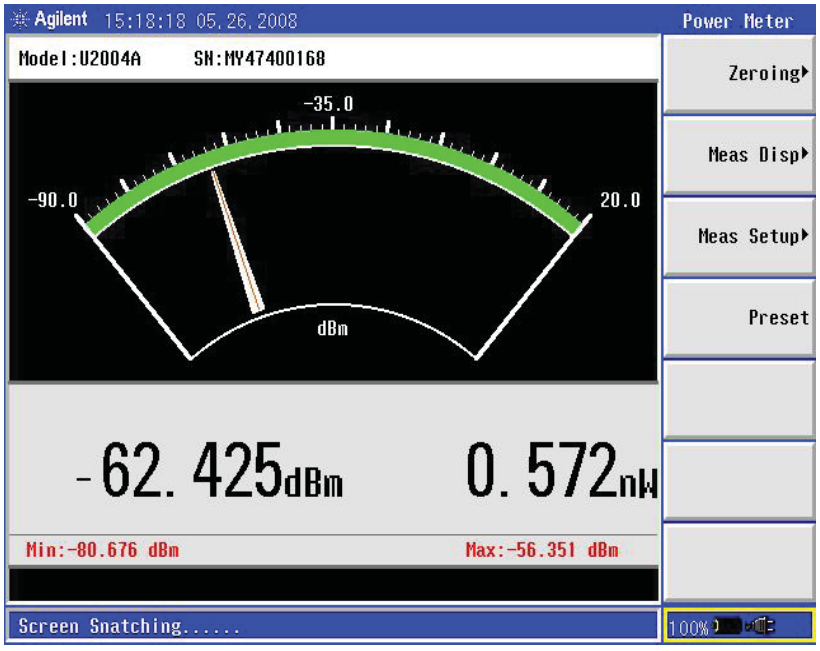


Figure 14 N9340A HHSA turns into a power-meter measurement

Power Meter Menu

- Zeroing: Access to zeroing and calibration menu
- Meas Disp: Access to measurement display menu and configure the displayed measurement resolution and format
- Meas Setup: Set up the relative measurement or set display offsets.
- Preset: Preset the USB power sensor

Instructions

3. Press {Zeroing ►} to perform the Internal or External Zeroing if necessary (see Figure 15).

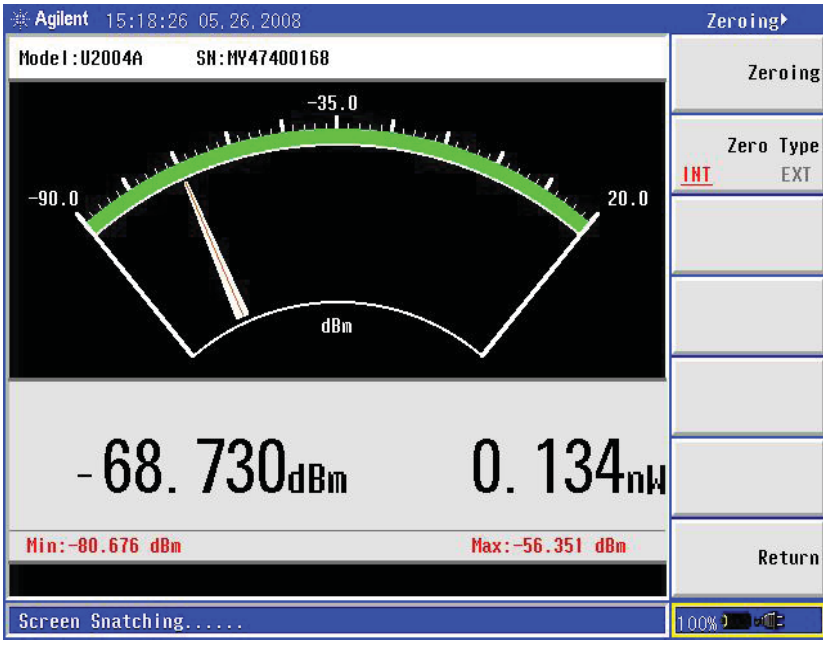


Figure 15 External and Internal Zeroing are performed to reduce the zero offset and noise impact in order to measure power accurately

Internal Zeroing

Internal zeroing uses an electronic switch to isolate the power sensor bulkhead from the internal measurement circuitry during the procedure, thereby allowing the sensor to be physically connected to an active RF source when internally zeroing. Therefore, you do not need to disconnect the RF source or power off the external source during an internal zero procedure. This feature makes internal zeroing more convenient, but you may only use internal zeroing if zero set (Internal) is within the application requirements.

External Zeroing

In external zeroing, the sensor does not utilize the electronic switch to isolate the measurement circuitry from the bulkhead. In this case, the RF power must be removed from the bulkhead either by turning the source off or physically removing it from the sensor during the external zero procedure. External zeroing generally has better zero set performance. The INT or EXT zeroing selection should be made based on the measurement needs.

By default, internal zeroing is performed by the firmware when the USB sensor is connected to N9340A HHSA.

4. Press {Return}. Press {Meas Disp ▶} (see Figure 16).

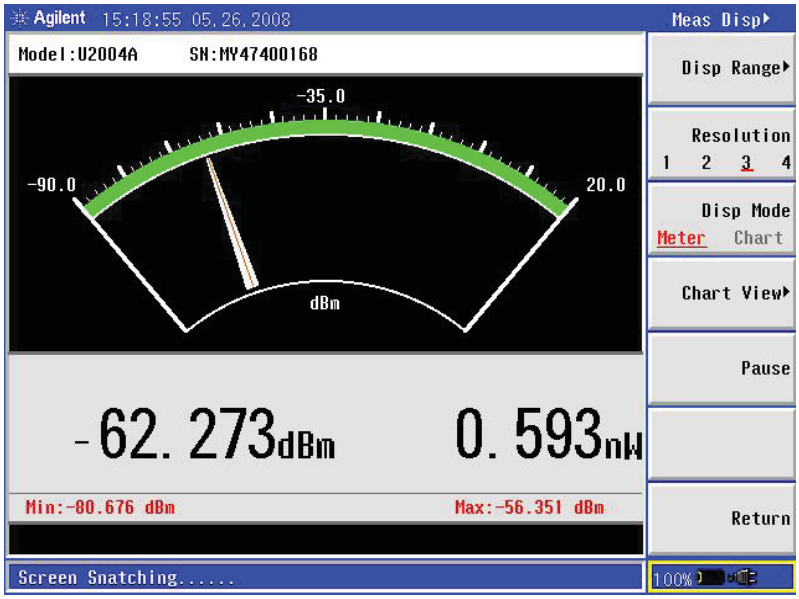


Figure 16 Meas Disp menu allows you to configure the display measurement and resolution

The Meas Disp (Measurement Display) menu allows you to configure the measurement display as follows:

- Disp Range: Indicates the top and bottom range of display measurement.
- Resolution: Indicates the measurement resolution's numeric type in four different levels (1, 2, 3 or 4). The default Resolution is 3.
- Disp Mode: You can configure the measurement display either in meter or chart format. The default Disp Mode is Meter.
- Chart View: Switches the measurement display to chart view
- Pause: Pause or continue the measurements

To view the measurement in chart or graph format, press {Disp Mode} to select {Chart} (see Figure 17).

Figure 17 Measurement display in chart format

Instructions

5. Press {Return}. Press {Meas Setup} (see Figure 18).

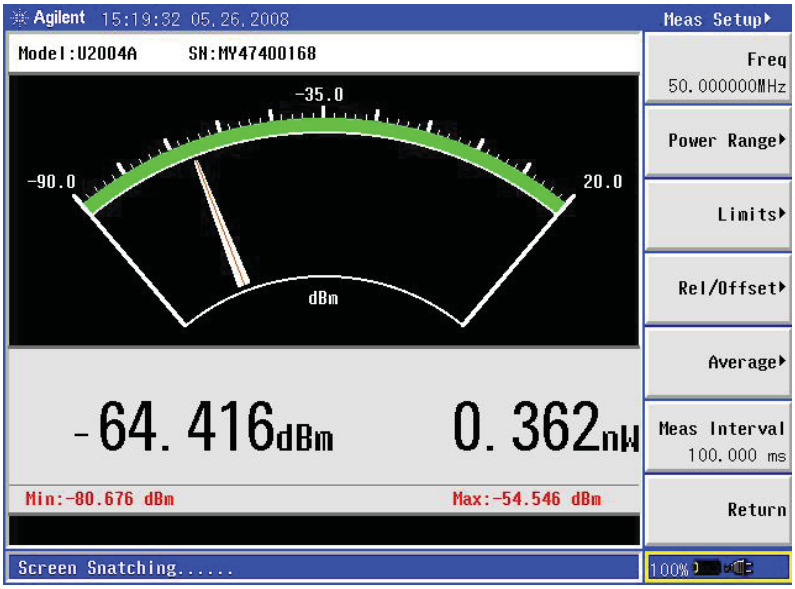


Figure 18 Measurement Setup menu with meter-view display measurement

Meas Setup (Measurement Setup) menu allows you to set up the relative measurement or set display offsets.

- Freq: Allows setting for the frequency of the RF signal that you are measuring. It optimizes the accuracy and minimizes measurement uncertainty, especially when making comparative measurements between signals.

- Power Range: Allows you to set the power range either in Auto or Manual. You are encouraged to use Auto range when they are not sure of the power level they are about to measure.
  In Manual range, there are two manual setting: “LOWER” and “UPPER”. LOWER range covers the power from -60 to -10dBm. UPPER range covers the power from -10 to +20dBm.

- Limits: Indicates the measurement result is beyond the configured upper or lower limit.

- Rel/Offset: Rel (Relative) mode enables comparison of a measurement result to a reference value. The relative reading, or difference, can be displayed in either dB or % terms. Offset setting can be configured to compensate for signal loss or gain (in dB) in your test setup.

- Averaging: Allows you to set the measurement averaging in Auto or Manual mode, to average power readings.
  The purpose of averaging is to reduce noise, obtain the desired resolution, and to reduce the jitter in the measurement results. Increasing the value of the measurement average reduces measurement noise, but the measurement time is increased. The default of Averaging is Auto.

- Step Detect: Used to reduce the filter settling time after a significant step in the measured power. The filter can be set to re-initialize upon detection of a step increase or decrease in the measured power.

- Meas Interval: Allows you to set the time (in s or ms) to capture the new power measurement continuously.

How Does It Work? (continued)

N5183A MXG Signal Generator

- To perform user flatness correction (UFC) with external leveling to improve power accuracy and flatness.

- To provide dual display measurement of two USB power sensors.

User flatness correction with external leveling provides the ability to have extremely flat output power at the testing interface beyond the signal generator RF output connector. If an external device (such as amplifier, attenuator, coupler, detector, divider or long cable) is placed between the RF output connector and the testing interface, it will introduce additional gain or loss as well as frequency response mismatch to the whole system. Therefore it is necessary to perform the UFC with external leveling to remove this type of influence.

In this case, the U2000 Series USB power sensor offers a solution integrated with the MXG. The U2000 Series USB power sensor is directly connected to front panel's USB port of MXG (see Figure 19) provides remote programming function. The MXG's built-in UFC personality will allow you to configure the calibration array, start and stop frequency and number of the frequency points to be corrected. The setup function thus will observe the difference between measured power and calibrated power. The correction factors of the UFC process are shown as in Figure 20.

For details of operation and procedure on UFC with external leveling and power measurement, please refer to "Agilent How to Utilize User Flatness Correction with External Leveling Using USB Power Sensor on MXG Signal Generator, Application Note" and "Agilent N5161A/62A/81A/82A/83A MXG Signal Generators, User's Guide".

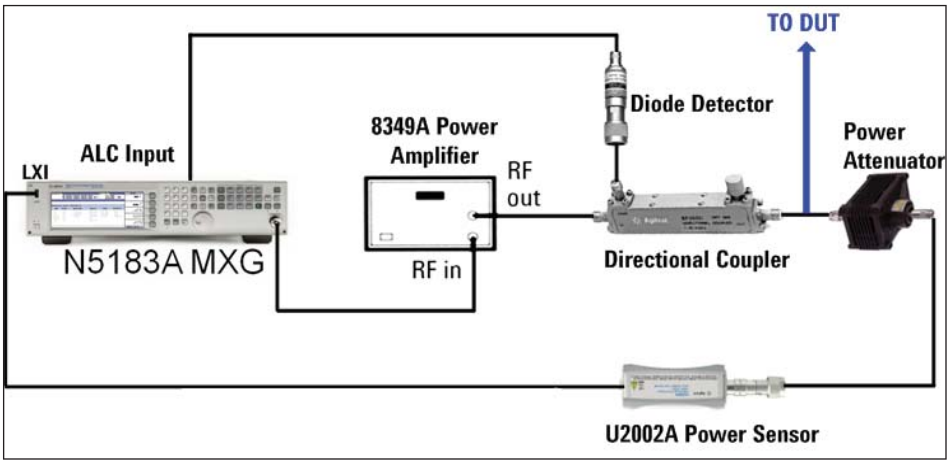


Figure 19 Connection diagram of USB sensor to MXG for UFC external leveling

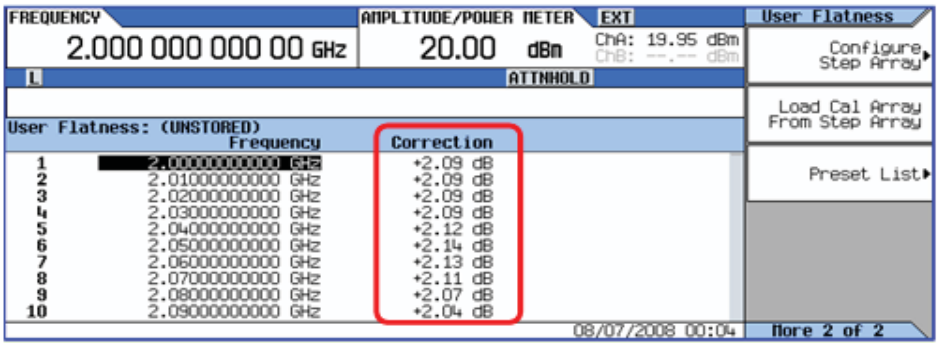


Figure 20 Correction factors automatically performed and display on MXG

Dual Power Meter Display Function on MXG

The dual power meter display function can be used to display the current frequency and average power of either one or two power sensors. For each channel, you can control the settings for On/Off, channel frequency, channel offset, averaging and measurement units, and the dual power meter display feature. To use two U2000 series power sensors with the MXG, an USB hub (with power supply) can be connected to the MXG's front panel USB connector (see figure 21). Figure 22 shows the dual power meter display function on MXG signal generator.

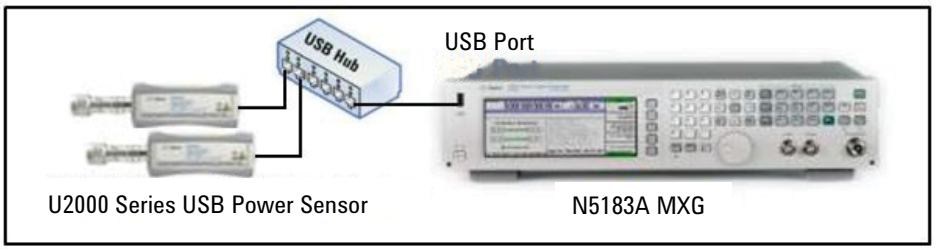


Figure 21 Connection diagram of two USB power sensors on MXG via external USB hub

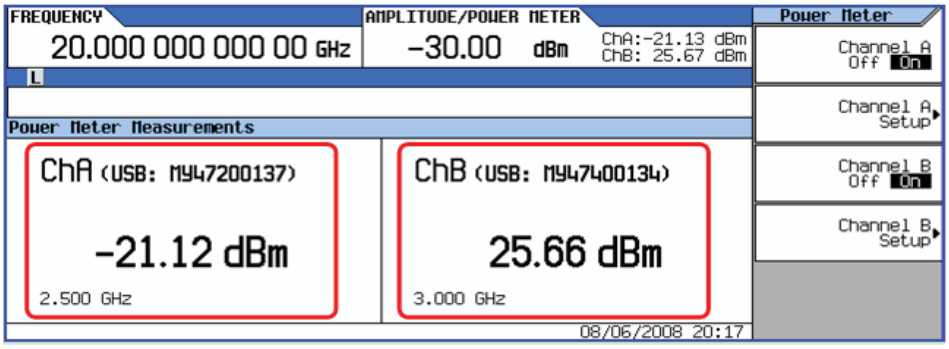


Figure 22 Dual power meter display function on MXG signal generator

Conclusion

The U2000 Series USB power sensors are compact and portable, easy to use, and cost effective for you as it provides the following benefits:

- Compatibility with other Agilent instruments such as vector network analyzer, spectrum analyzer, signal generator, cable and antenna tester, and FieldFox RF analyzer.
- Portability for field application. The smaller size and light weight of the USB power sensors allow you to carry it to the site for field applications.
- Simplified measurement setup with USB power, plug-and-play connectivity, and built-in triggering circuit.
- Lower cost without compromising on performance or quality. Standalone USB power sensors do not need a power meter to provide accurate power measurement via PC/ laptop or other Agilent instruments.

Related Literature

[1] *Agilent U2000 Series USB Power Sensors, Technical Overview*
Literature Number: 5989-6279EN

[2] *Agilent N9340A Handheld Spectrum Analyzer, Technical Overview*
Literature Number: 5989-5071EN

[3] *Agilent Handheld Cable and Antenna Tester, Technical Overview*
Literature Number: 5989-5522EN

[4] *Agilent Simple Scalar Network Analysis of Frequency Converter Devices using the U2000 USB Power Sensor Series with the ENA Network Analyzer, Application Note*
Literature Number: 5989-8689EN

Product Web Site

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Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 375 8100

Europe & Middle East

Belgium	32 (0) 2 404 93 40
Denmark	45 45 80 12 15
Finland	358 (0) 10 855 2100
France	0825 010 700* *0.125 €/minute
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
United Kingdom	44 (0) 118 927 6201

For other unlisted countries:
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